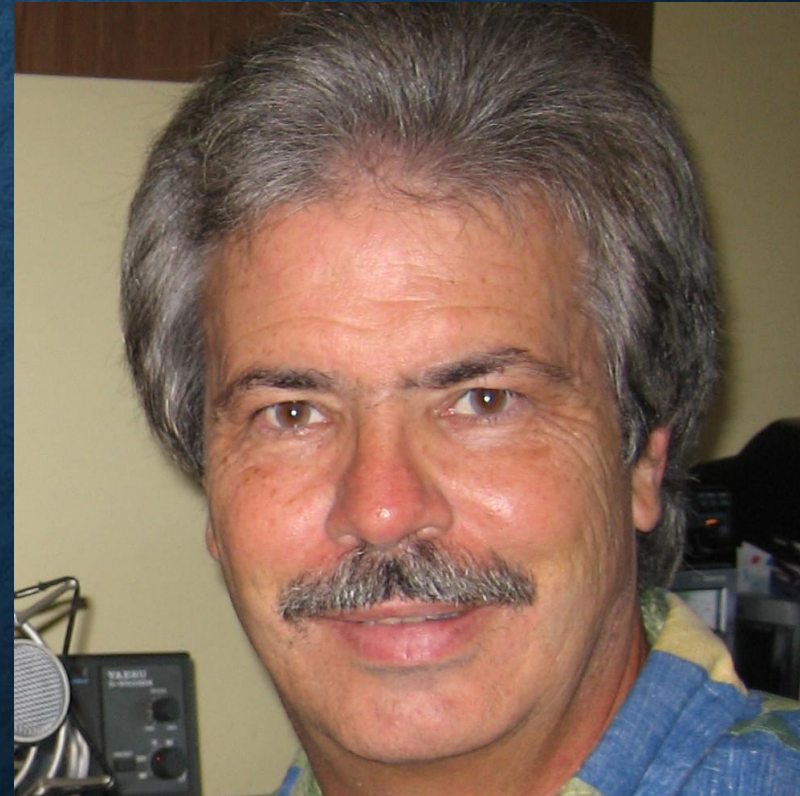


ULTRA-LIGHT HIGH-PERFORMANCE YAGIS FOR FIELD DAY

Presented by
Chip Margelli, K7JA
Pacificon 2021



CONFESSION: I AM A FIELD DAY JUNKIE

“Be Loud, or Be Hosed”

I don't like to be hosed.



CONFESSION: I AM A FIELD DAY JUNKIE

Major Character Flaw:
I can't even do a Field
Day VHF Station
“half way.”



THE DREAM



Who wouldn't want a
W3AO-style lineup of stout
beams on tall masts, put up
by someone else?

THE PROBLEMS

- I'm getting to old for this shtuff (I often am *the* infrastructure at Field Day).



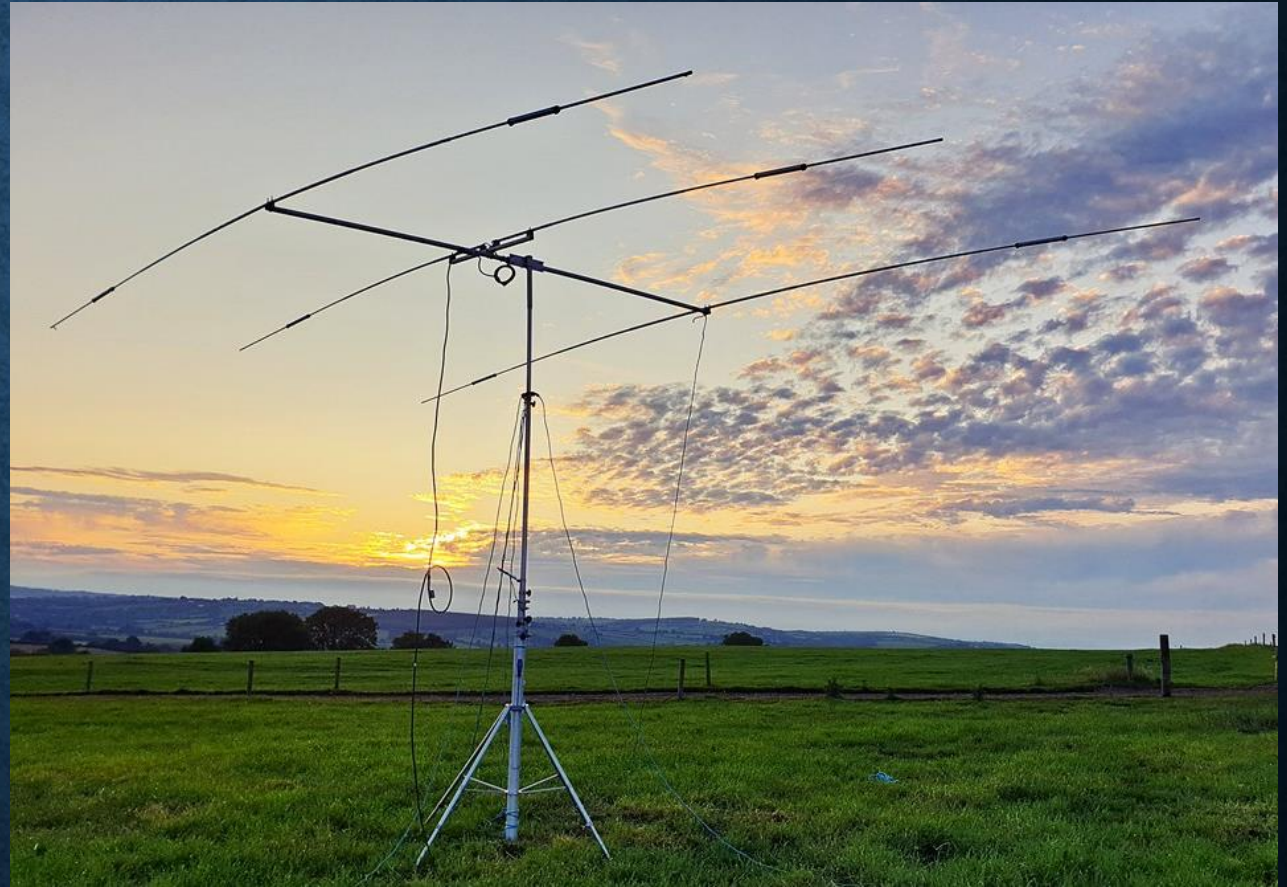
THE PROBLEMS

Traditional Axiom:
Loud beams are heavy
(Hy-Gain 204BA: 50 lb)



THE PROBLEMS

Traditional Axiom 2:
It's really hard to raise
an aluminum beam
higher than 20' on a
DXpedition. Or for
CQP Roving.



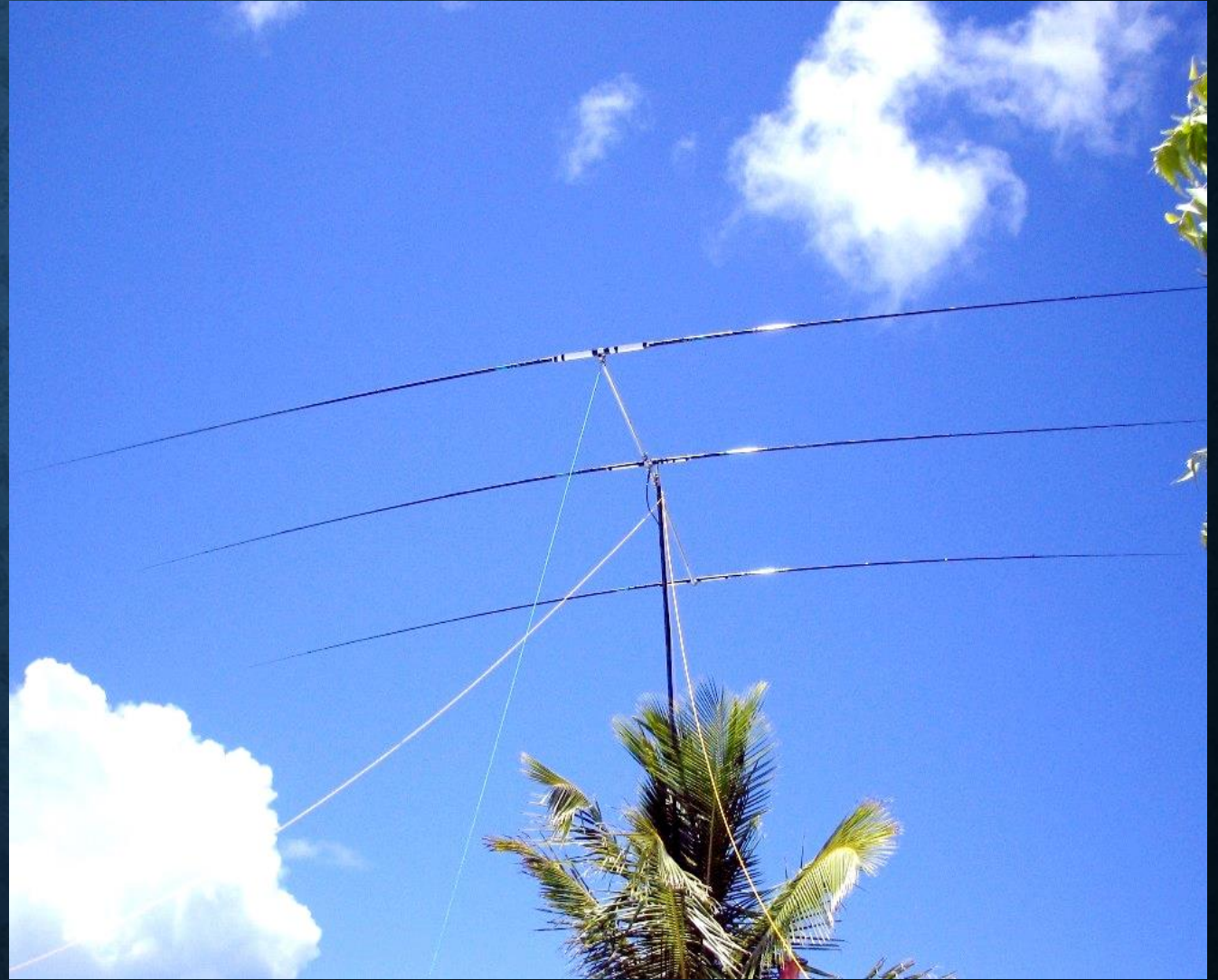
POTENTIAL SOLUTION

Make the loud
beam lighter
(light beams can
be raised higher
than heavy
beams)!



POTENTIAL SOLUTION

Use fiberglass
fishing poles
to support Yagi-
style elements
made of copper
wire.

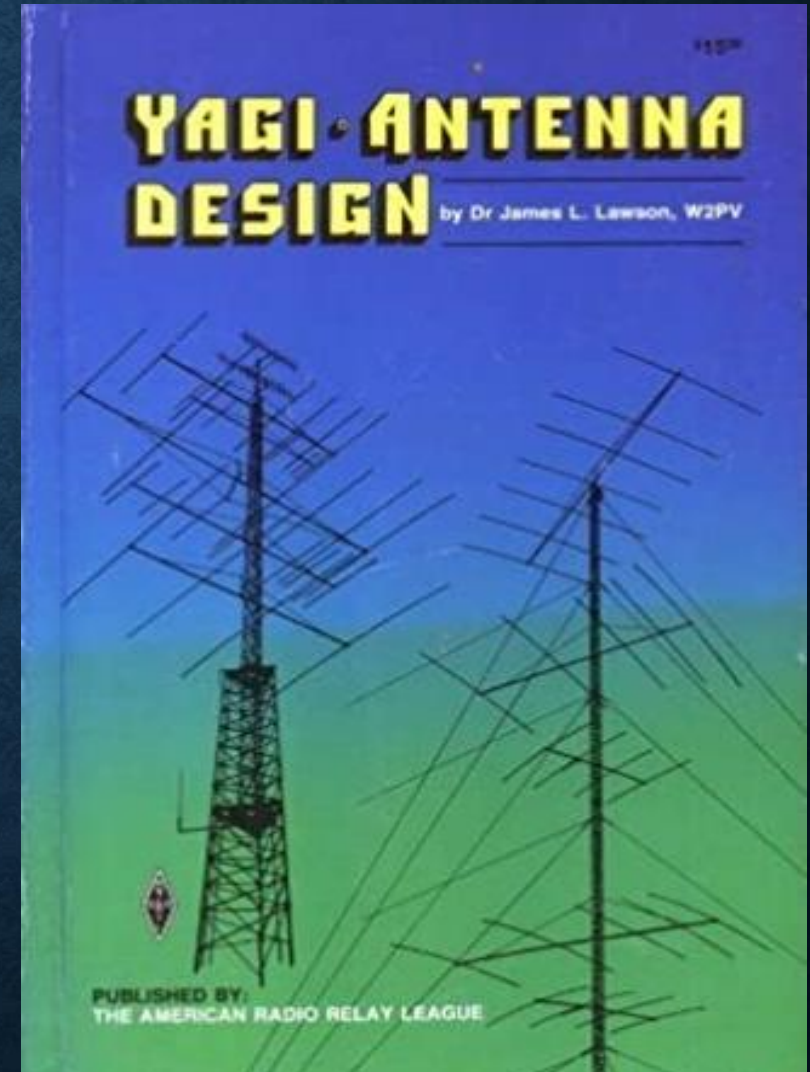


POTENTIAL SOLUTION

- Original design idea came from QST article in July 2001 (p. 28) by David Reid, PA3HBB.
- Design was for a 3-element 14 MHz Yagi.
- I built it, and it didn't resonate where expected.
- The "WHY?" of this, and the solutions, will be discussed today.

ACKNOWLEDGMENT: W2PV

Classic treatise on computer design of HF Yagis includes invaluable lessons on the scaling of designs using different materials. Thanks to Dr. Jim Lawson, W2PV.



SO WHAT'S THE CATCH?

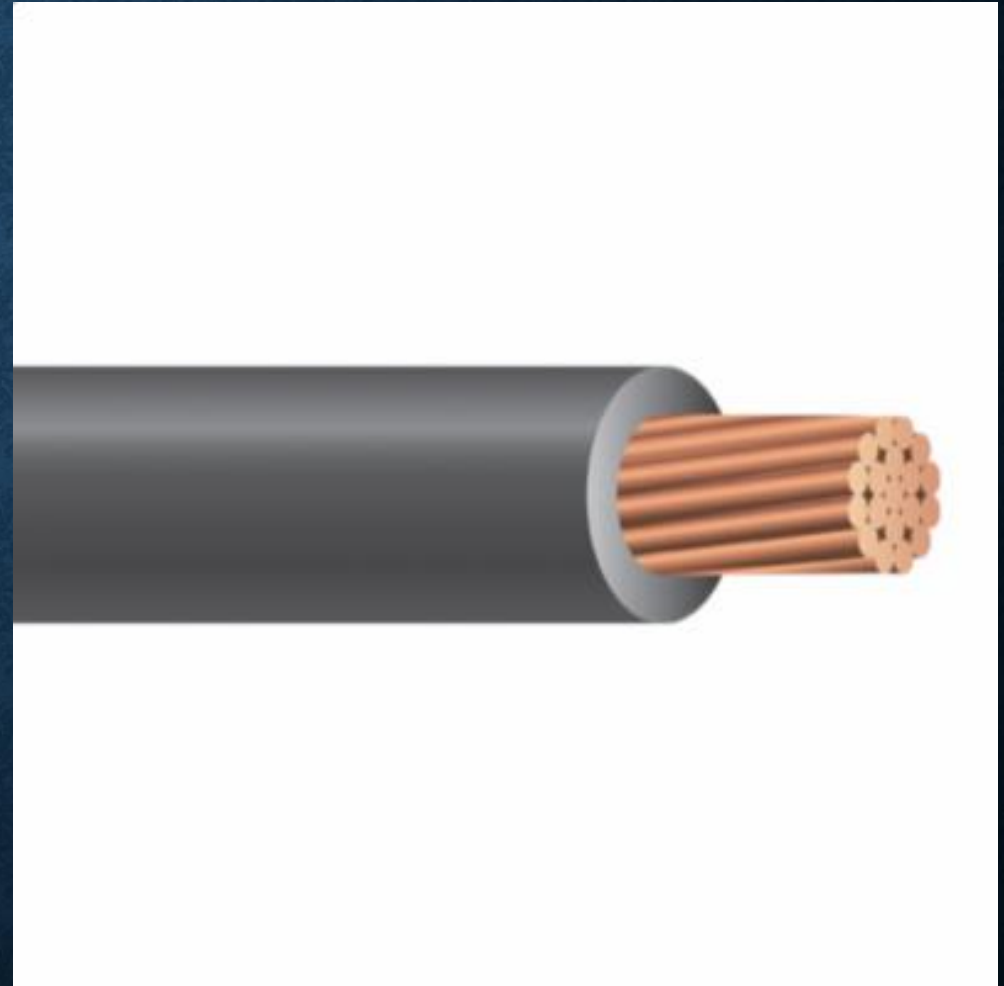
Two Words: Dielectric Effect

DIELECTRIC EFFECT

The resonant length of a “half-wavelength” Dipole is different for bare wire and insulated wire.

20m Dipole Lr (Bare) = 404”

20m Dipole Lr (Ins.) = 396”



DIELECTRIC EFFECT

Bare wire applied to the surface of a fiberglass tube is subject to the same kind of dielectric loading effect.



DIELECTRIC EFFECT

Design Challenges

- Dielectric Characteristics of Poles Used
- Diameters of Poles Used
- Tightness and Spacing of Tape Wrap
- *Important: Poles must be pure Fiberglass, with no Carbon Fiber!*

RECOMMENDED PARTS



B&M Black Widow Crappie Poles

100% Fiberglass

Available in 10' (BW3-6M), 13' (BW4-10M), 16.5' (BW5-15/20M), and
20' (BW6-40M) sizes

RECOMMENDED PARTS



Angle Aluminum (Home Depot, etc.)

1" sides (20-10M), $\frac{3}{4}$ " sides (6M)

RECOMMENDED PARTS



Aluminum Tubing (6061-T6 best) for Boom
(Objective: As light as possible for desired length)

10/6M (12' Boom): 1.125" Center, 1.00" ends

15M (12' Boom): 1.25"/1.125"/1.00" taper

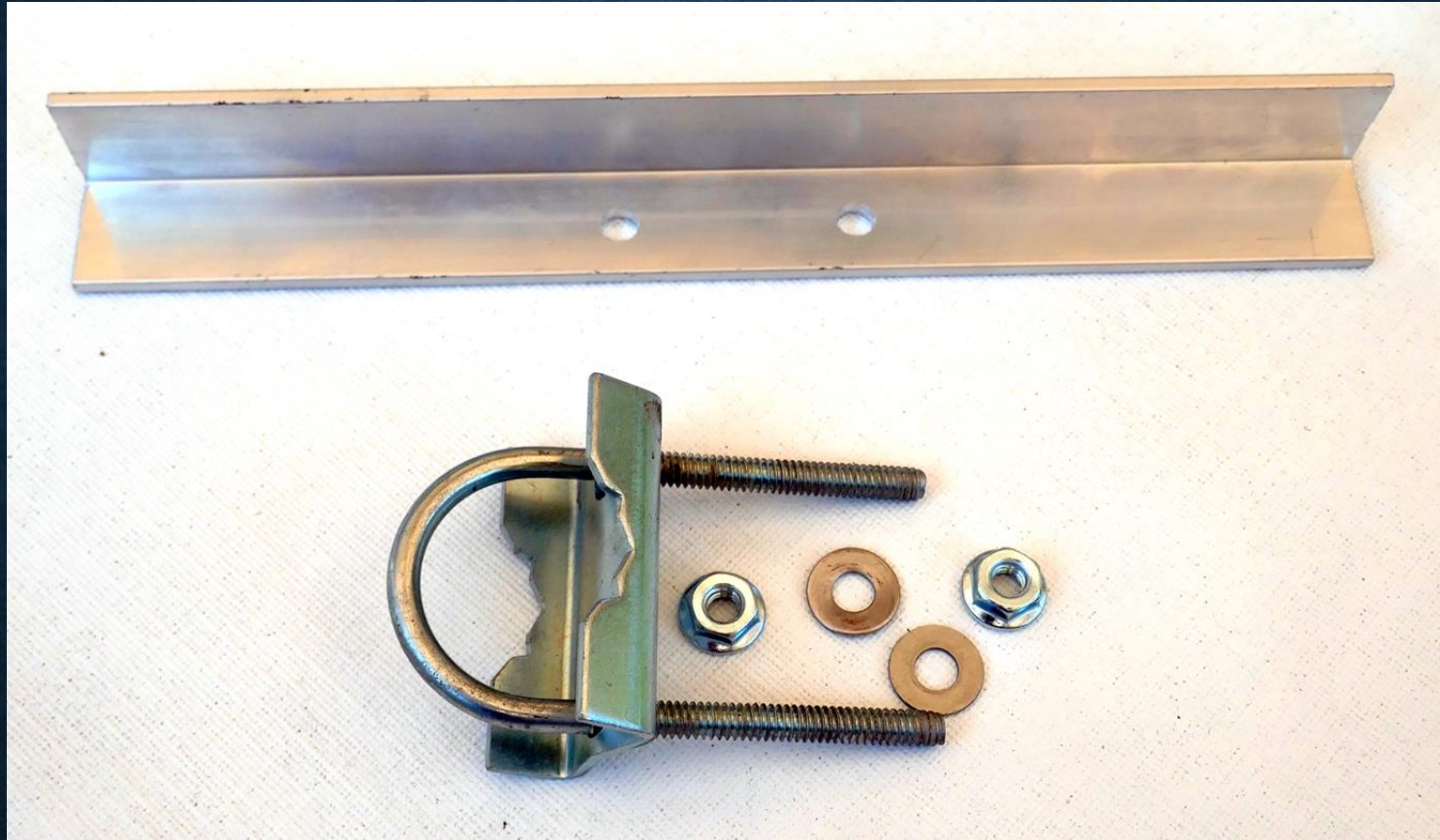
20M: 1.25" to 1.5", depending on # of elements

RECOMMENDED PARTS

(Miscellaneous)

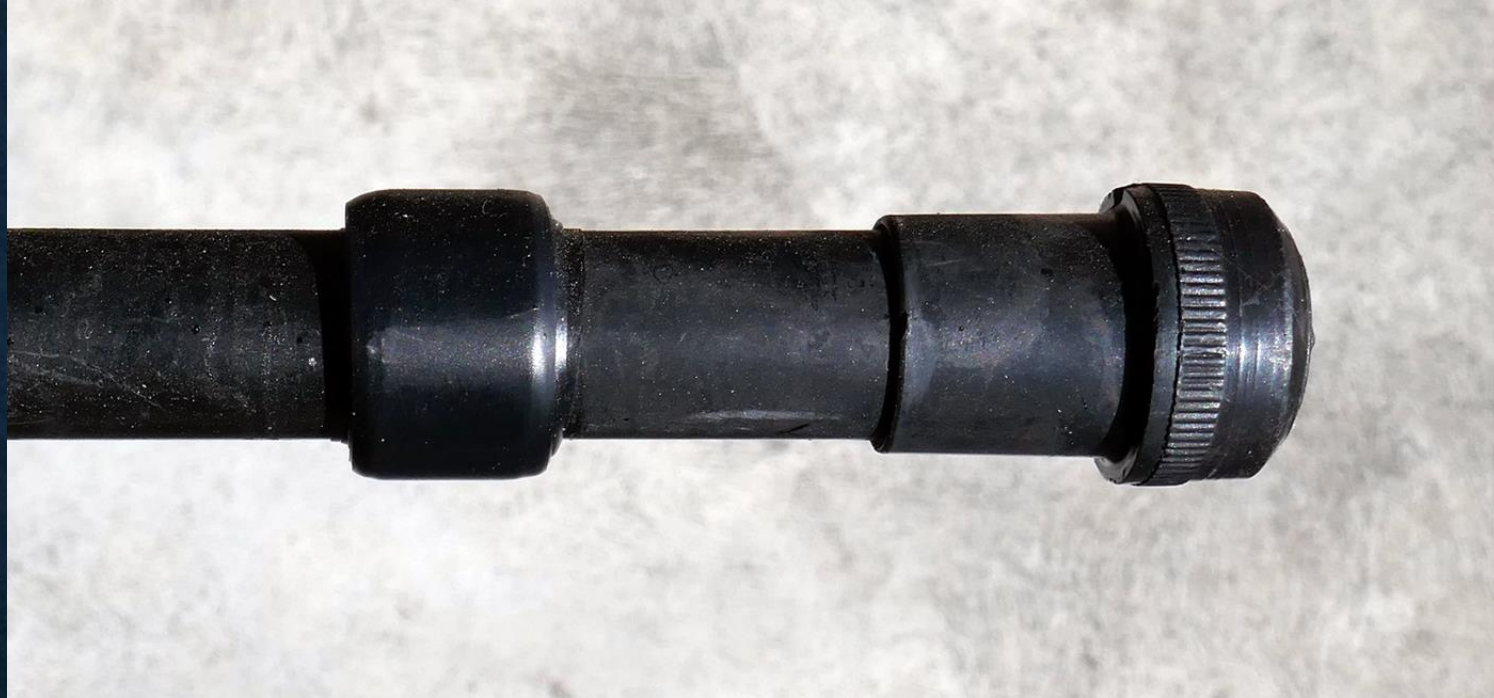
- TV U-bolts with Saddles (Radio Shack, etc.)
- Boom-to-Mast Mount (light as possible)
- 1:1 Current Balun
- Dacron Cord for Boom Support (20M) (maybe)

CONSTRUCTION BASICS



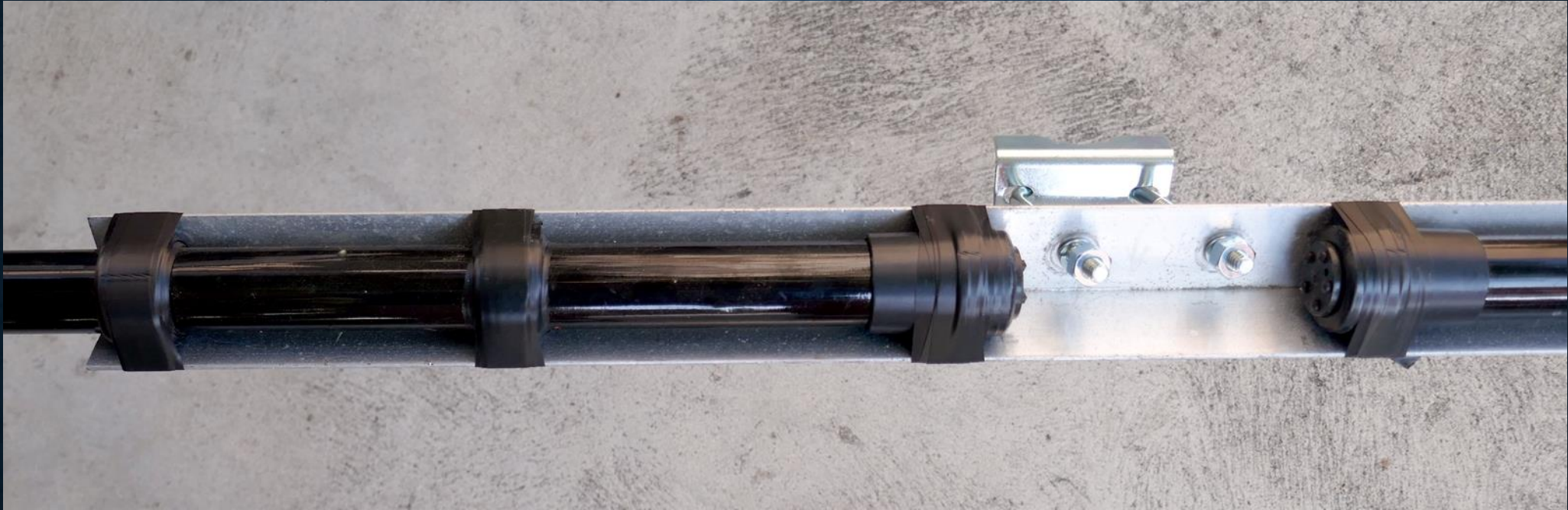
- Drill two $\frac{1}{4}$ " holes on one side of angle aluminum to accommodate TV U-bolts.

CONSTRUCTION BASICS



Tape the fishing pole about 30 layers deep to match the diameter of the cap at butt end of the fishing pole (to make element flat).

CONSTRUCTION BASICS



Tape each fishing pole to the angle aluminum, leaving room for nut driver to tighten the hardware without interference.

CONSTRUCTION BASICS

Mark the center of each parasitic element, then tape the elements to the poles 4-5 times per telescoping section.

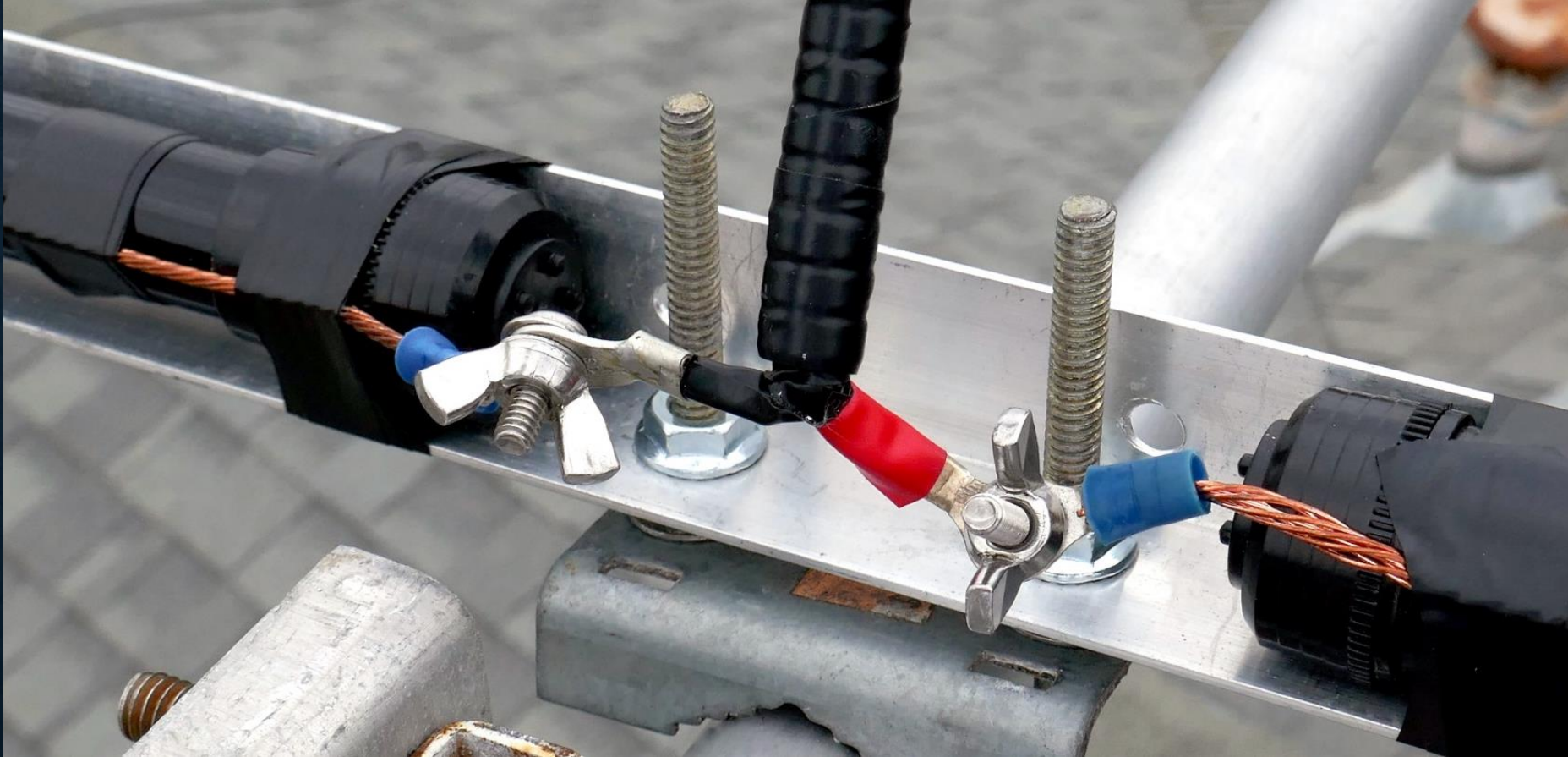


CONSTRUCTION BASICS

U-bolt is mounted to boom using two nuts, then element mount is slid over legs of U-bolt and secured with two more nuts. (Black tape on wire marks center of element)



CONSTRUCTION BASICS



In the case of the Driven Element, take care to prevent shorts from balun/wires to the U-bolt.

CONSTRUCTION BASICS

The Result?

A 2-pound 20-meter element!



SIDE BENEFIT...

Fiberglass element supports are nearly indestructible in high winds!

Welcome to Field Day in Wyoming at WY7FD.



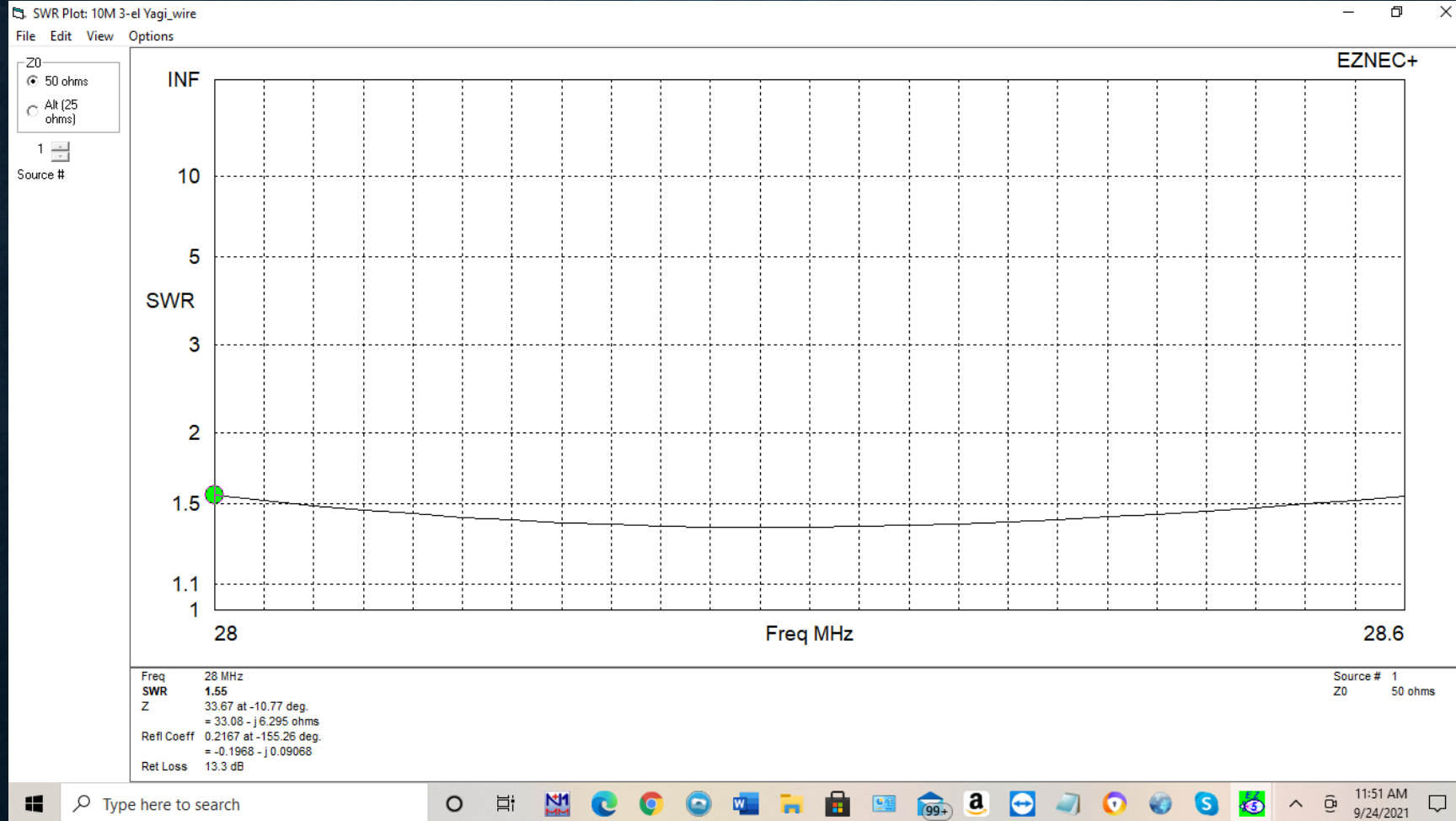
DESIGNING A BEAM

- Design a free-space model with native 50-Ohm feedpoint impedance and no dielectric.
- Remove parasitic element(s) from model and determine resonant frequency of DE alone.
- Mount DE wires on poles, elevate, and adjust length to match resonant frequency of model of DE by itself.
- Determine dielectric effect by data fit.
- Cut parasitics based on delta of lengths from free-space model and mount on poles. Test and enjoy!

DESIGN A 50-OHM BEAM

- Why 50-Ohm impedance? Matching networks will obscure total beam characteristics in this necessarily-empirical design process.
- A 50-Ohm native impedance beam will only be down a few tenths of a dB from gain of low impedance Yagi, and generally will be broader in SWR characteristics.
- Not necessary to have “50 Ohms” as feed Z; anything from about 37 to 65 Ohms OK.

DESIGN A 50-OHM BEAM



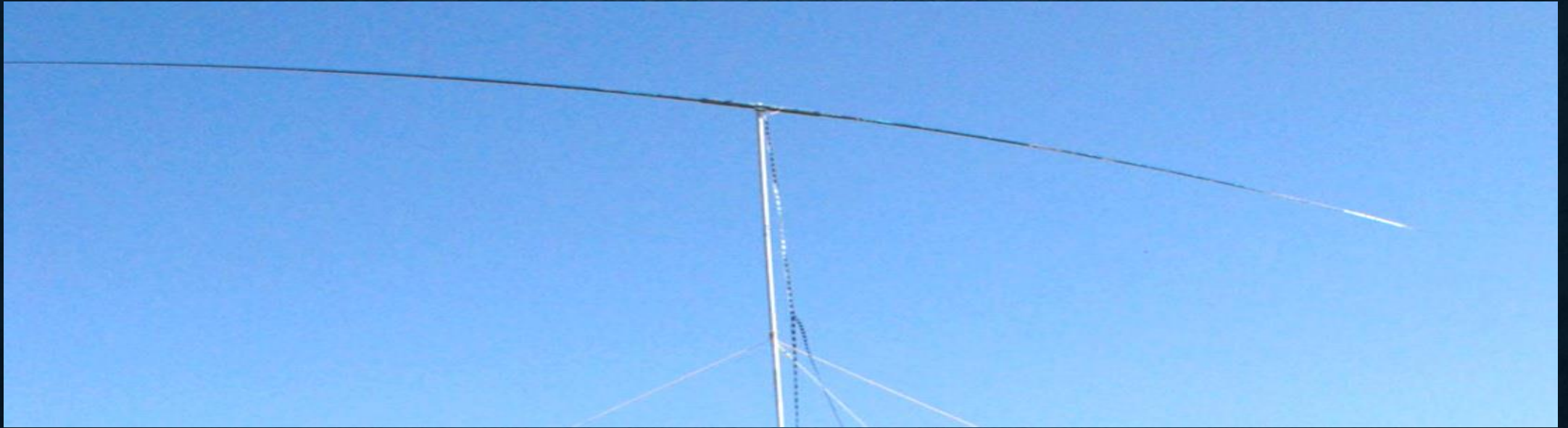
Broad-response 35-Ohm design can still have SWR less than 1.5:1 across much of 10 meters.

DESIGN A 50-OHM BEAM

Evaluating Stand-Alone Driven Element

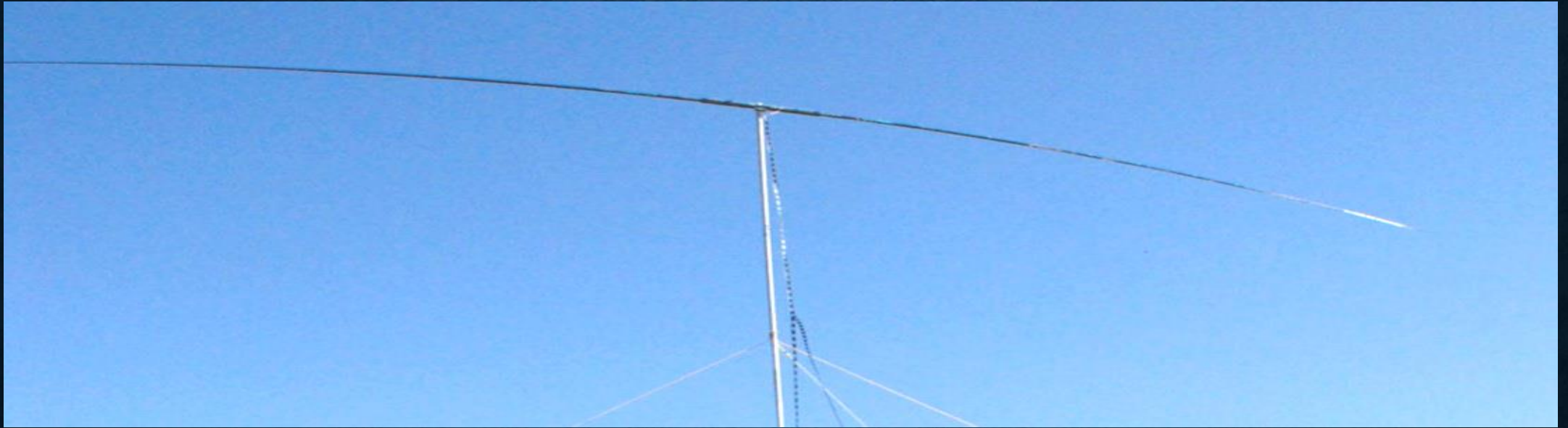
- Necessary in order to determine dielectric effect in next design step.
- Element lengths in Yagi are different when viewed alone as opposed to in array, due to mutual coupling.
- Example: Driver that (in array) resonates at 28.3 MHz can resonate at 27.4 MHz when parasitic elements are not present.

DESIGN A 50-OHM BEAM



Now mount the DE wires to the pole, using the dimensions of the DE alone and without any dielectric. At 20' or more, it will resonate at lower frequency yet, due to dielectric. Trim each side equally to return to original frequency (27.4 MHz in current example).

DESIGN A 50-OHM BEAM



Now You Can Build a Beam!

- Now we have a DE that will resonate at 28.3 MHz when the parasitic elements are added. Typical shortening on 10M: 103.5'' (off poles) => 101.25'' (on poles).

DESIGN A 50-OHM BEAM

Cut the Reflector and Director Element(s) using the same length difference from the DE as in the original bare-wire design. Then mount the parasitic elements to the boom.



RIGOROUS DESIGN SIDE TRIP

Figure out the dielectric effect of your poles

- Plug the 101.25" length into software with no dielectric. It will resonate above 27.4 MHz. Add dielectric to bring resonant frequency back to 27.4 MHz (in this case, Dielectric Constant of 1.22 and Thickness of 0.15" fits). This is equivalent to the 103.5" element with no dielectric, which in turn resonates at 28.3 MHz when parasitics are added!

TESTING THE ULTRALIGHT BEAM

Mount the Yagi as high and in the clear as reasonably possible, and test both SWR and pattern.



TESTING THE ULTRALIGHT BEAM

Testing alternative:

Point beam straight up!

This works best if butt end of boom is on plastic/wood chair or table. Results closely emulate beam at 60 feet elevation.



BEAM DESIGN RECAP

- Design 50-Ohm beam using bare #14 wire and verify performance across band. Note resonant frequency.
- In software, remove Reflector and Director(s) and determine resonant frequency of DE alone, without Reflector/Director(s).
- Mount #14 wire on poles for real-world DE, and prune to achieve same resonant frequency as in model in previous step.
- Mount wires for Reflector and Director(s) on poles, using same length difference as in bare-wire computer model.
- Test, verify, and enjoy.

ULTRALIGHT BEAM EXAMPLES: 20M

20M 2-el Yagi (DE+Ref1)

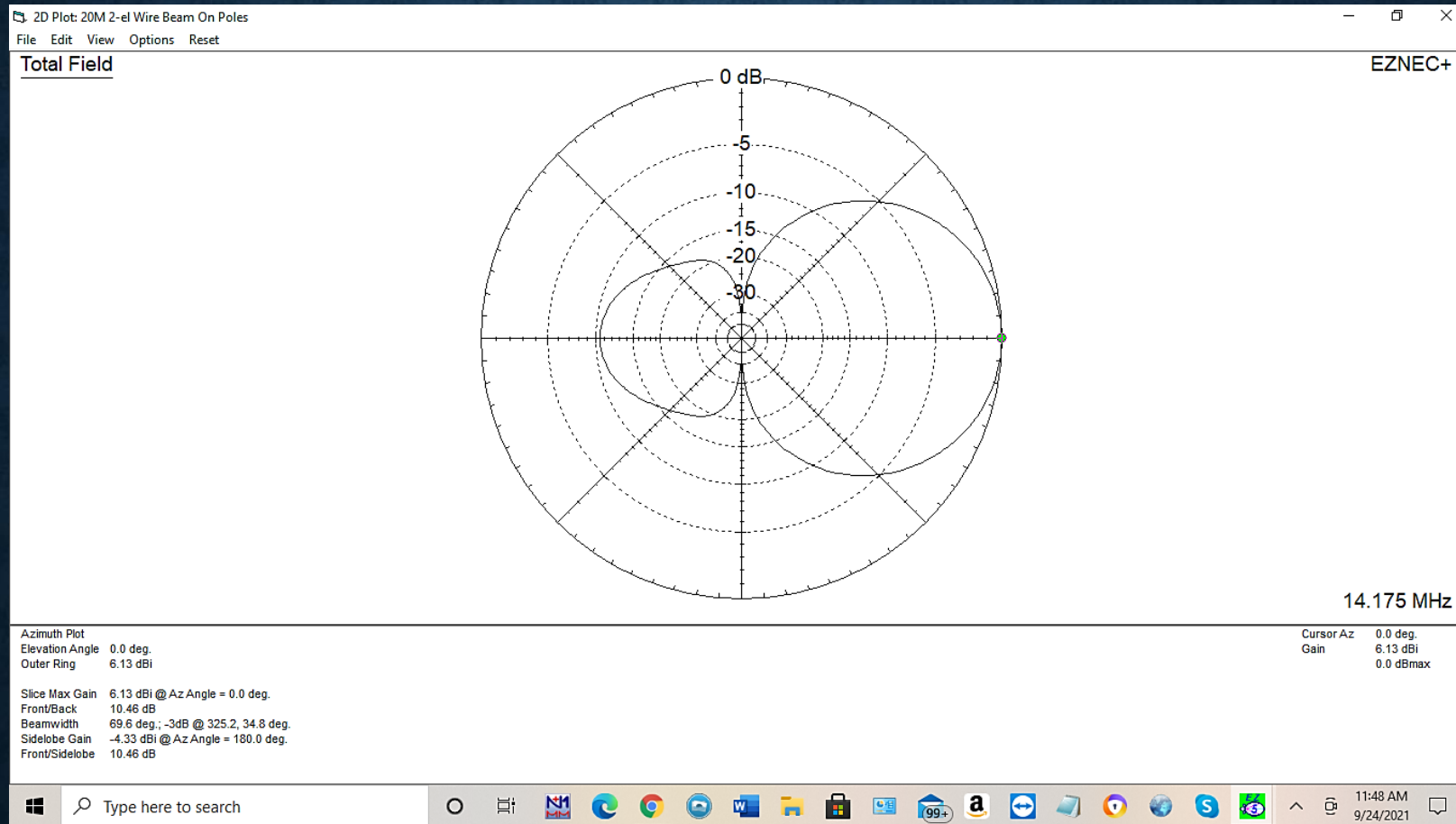
Boom Length: 12 Feet

Weight: About 12 Pounds

Used at W6ZE FD Site as a
“North” beam for NoCal/W7/VE7



ULTRALIGHT BEAM EXAMPLES: 20M

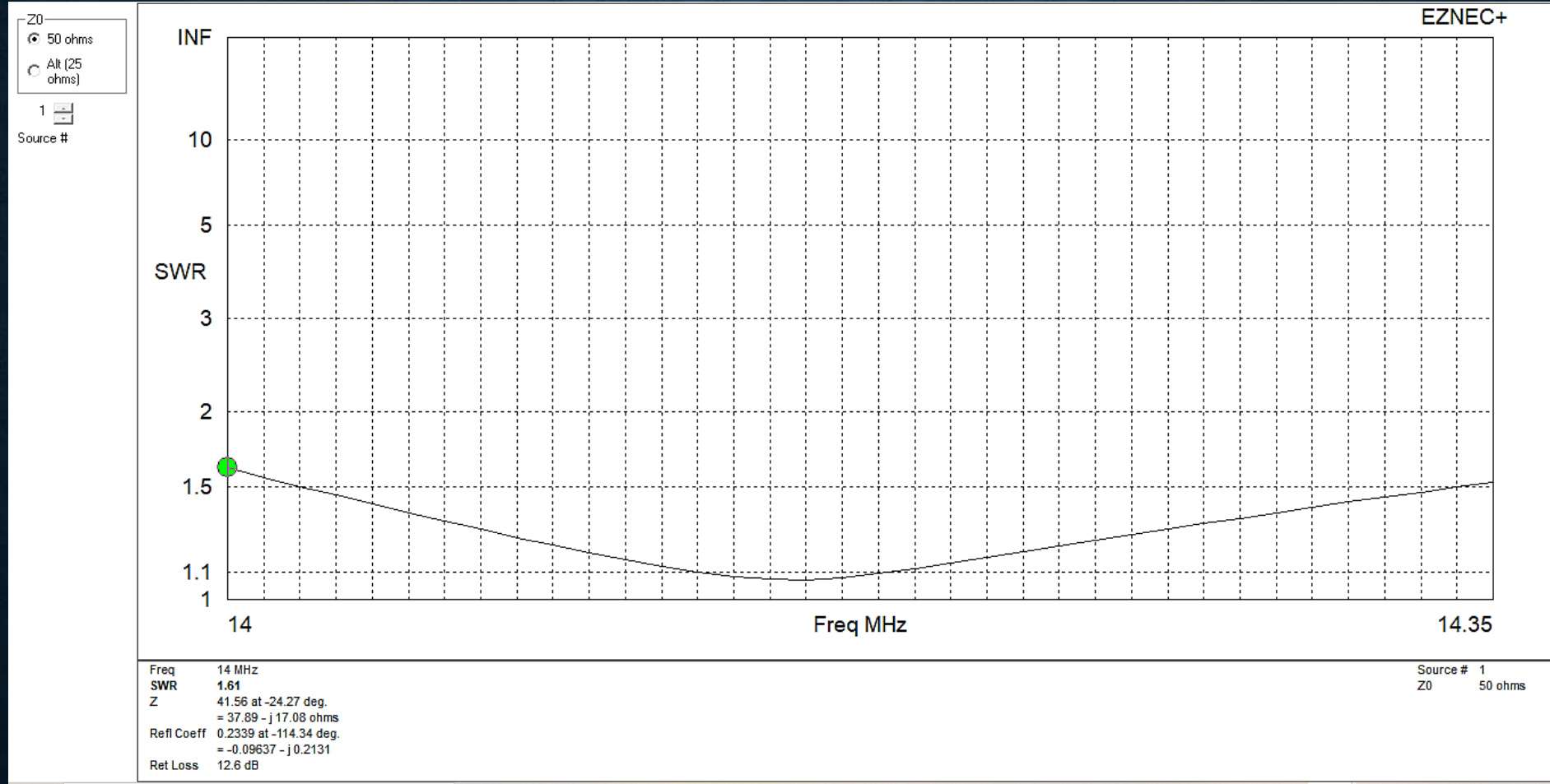


20M 2-el Yagi (DE+Ref1)

Gain = 6.13 dBi

F/B = 10.46 dB

ULTRALIGHT BEAM EXAMPLES: 20M



20M 2-el Yagi (DE+Refl)

SWR < 1.6:1 across entire band (1.07:1 @ 14.175 MHz)

ULTRALIGHT BEAM EXAMPLES: 20M

20M 3-el Yagi

Boom Length: 16.5 Feet

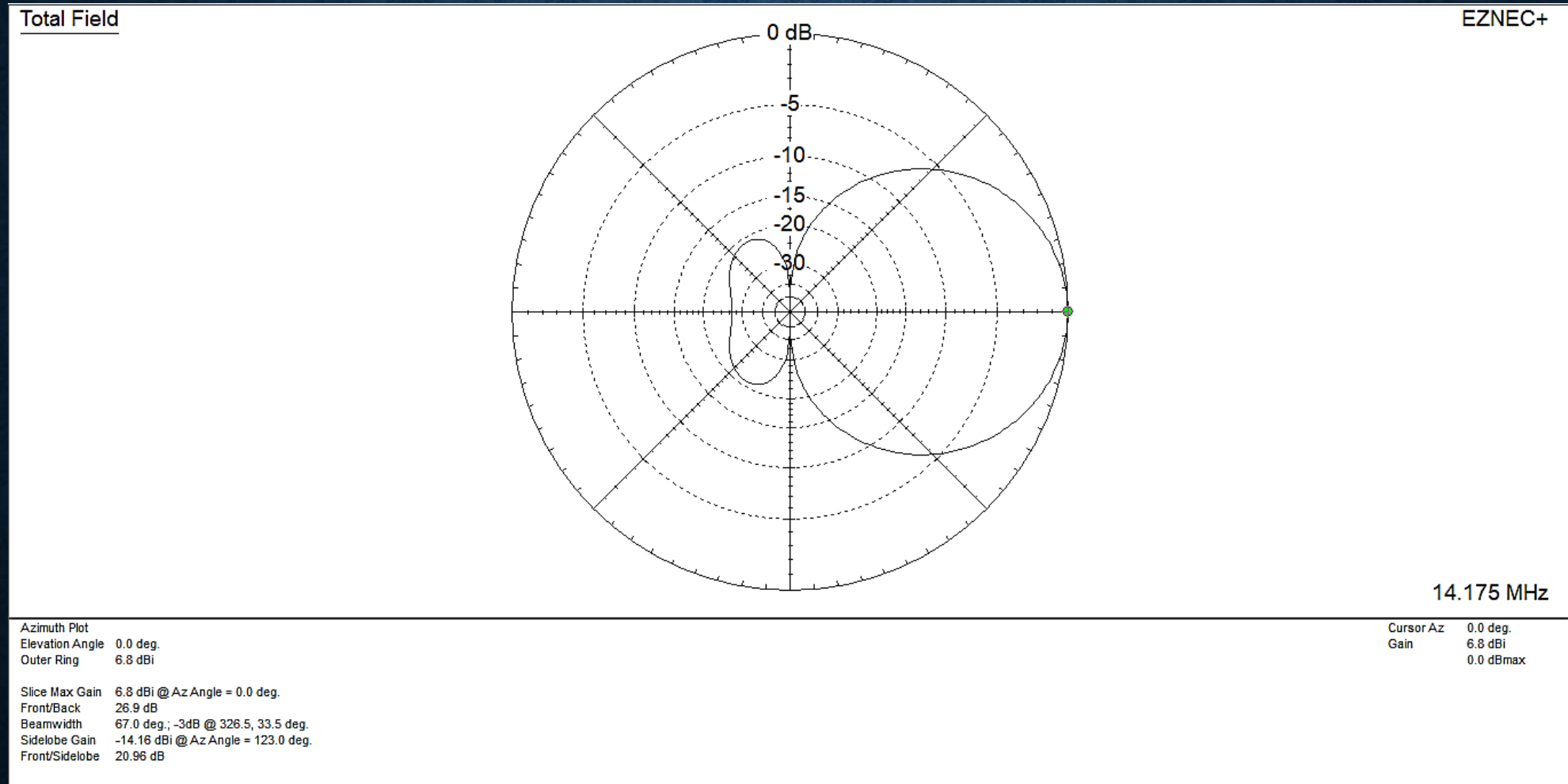
Weight: About 16 Pounds

Here deployed at KP2AA
Field Day Site on St. Croix

Piña Colada
Contest Club



ULTRALIGHT BEAM EXAMPLES: 20M

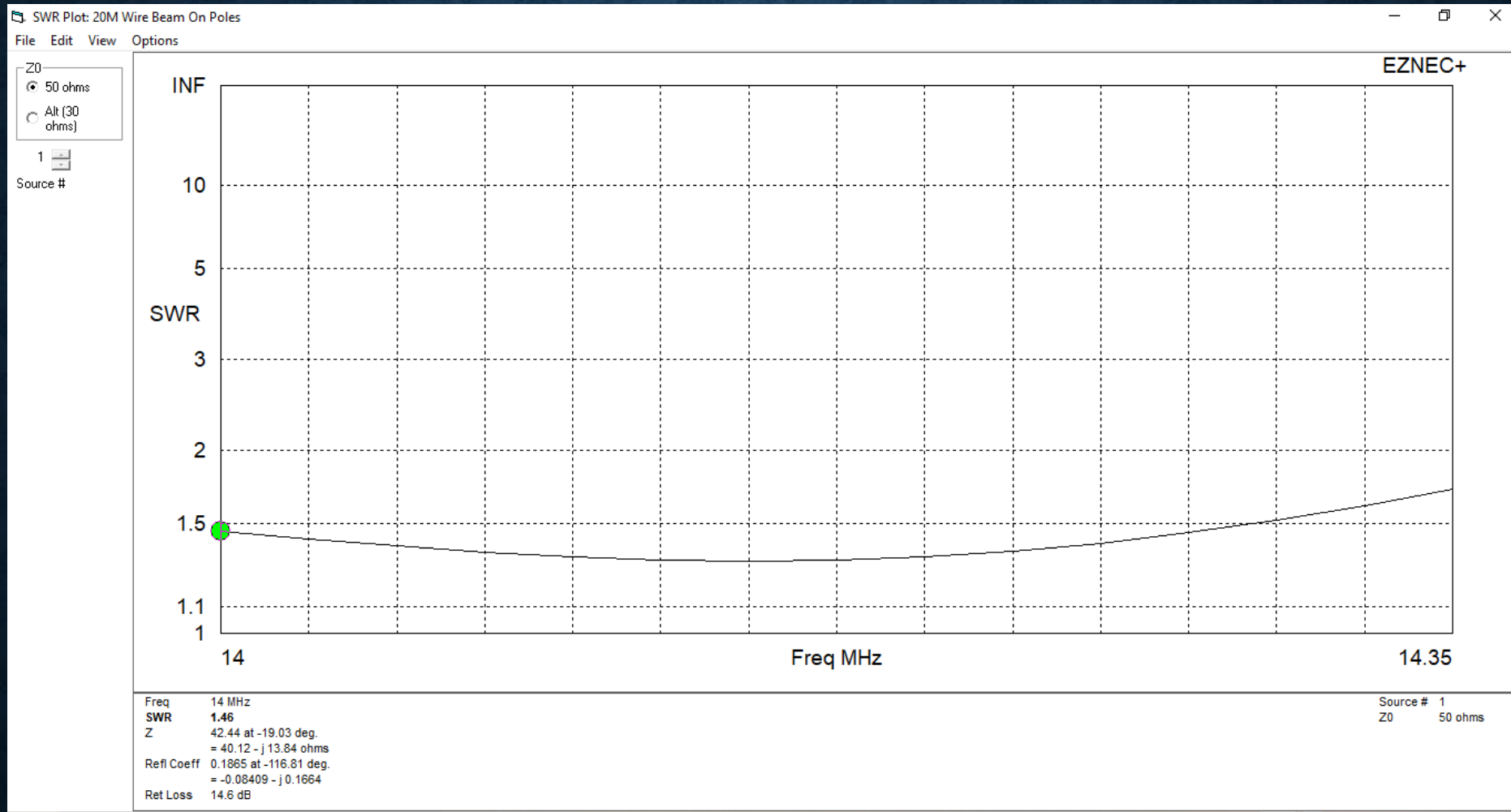


20M 3-el Yagi

Gain = 6.8 dBi

F/B = 26.9 dB

ULTRALIGHT BEAM EXAMPLES: 20M



20M 3-el Yagi

SWR < 1.5:1 at 14.0 – 14.3 MHz (1.3:1 @ 14.175 MHz)

ULTRALIGHT BEAM EXAMPLES: 20M

20M 4-el Yagi

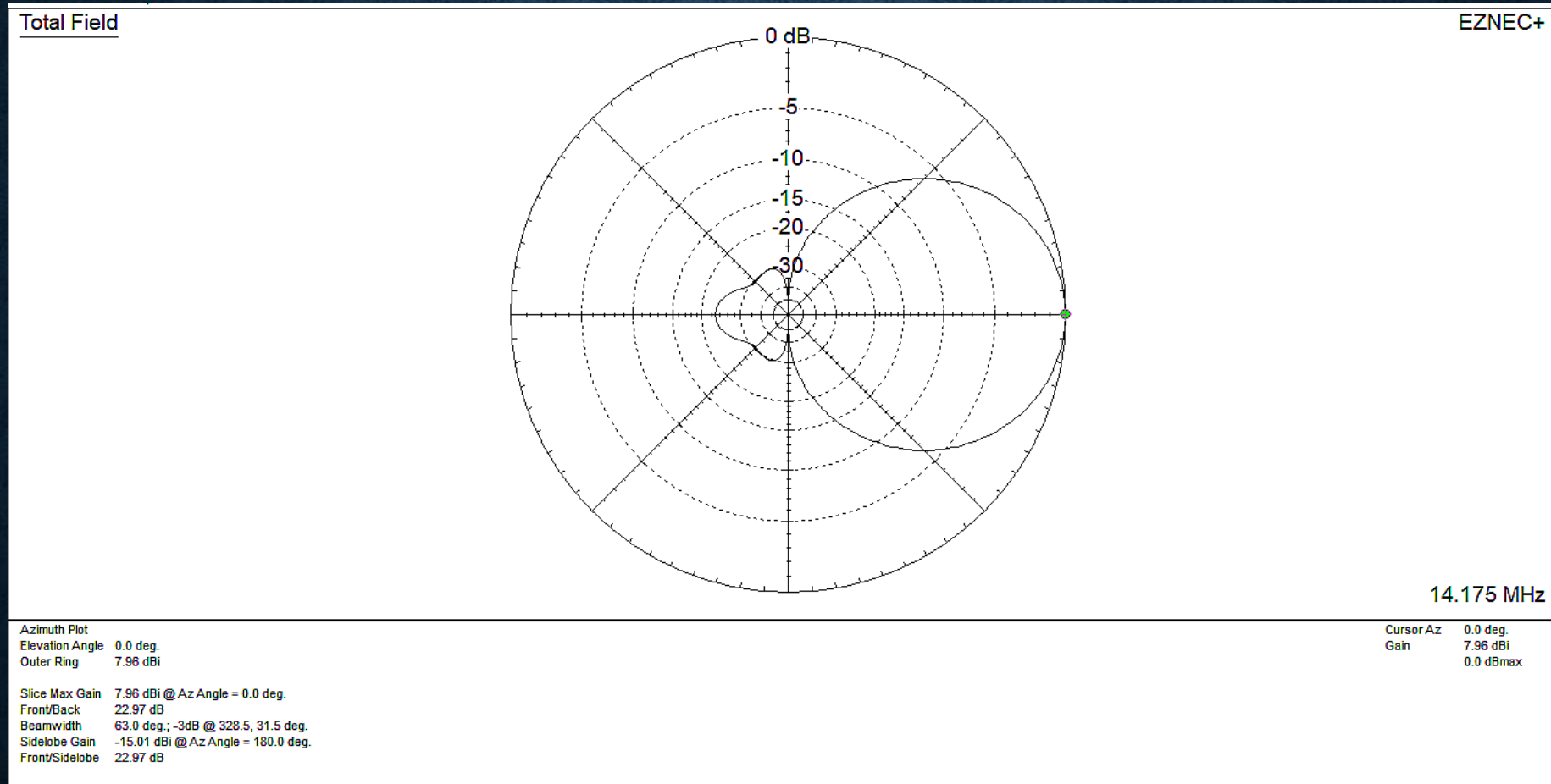
Boom Length: 25 Feet

Weight: About 20 Pounds

Used at W6ZE FD and
WFD as “East” Beam



ULTRALIGHT BEAM EXAMPLES: 20M

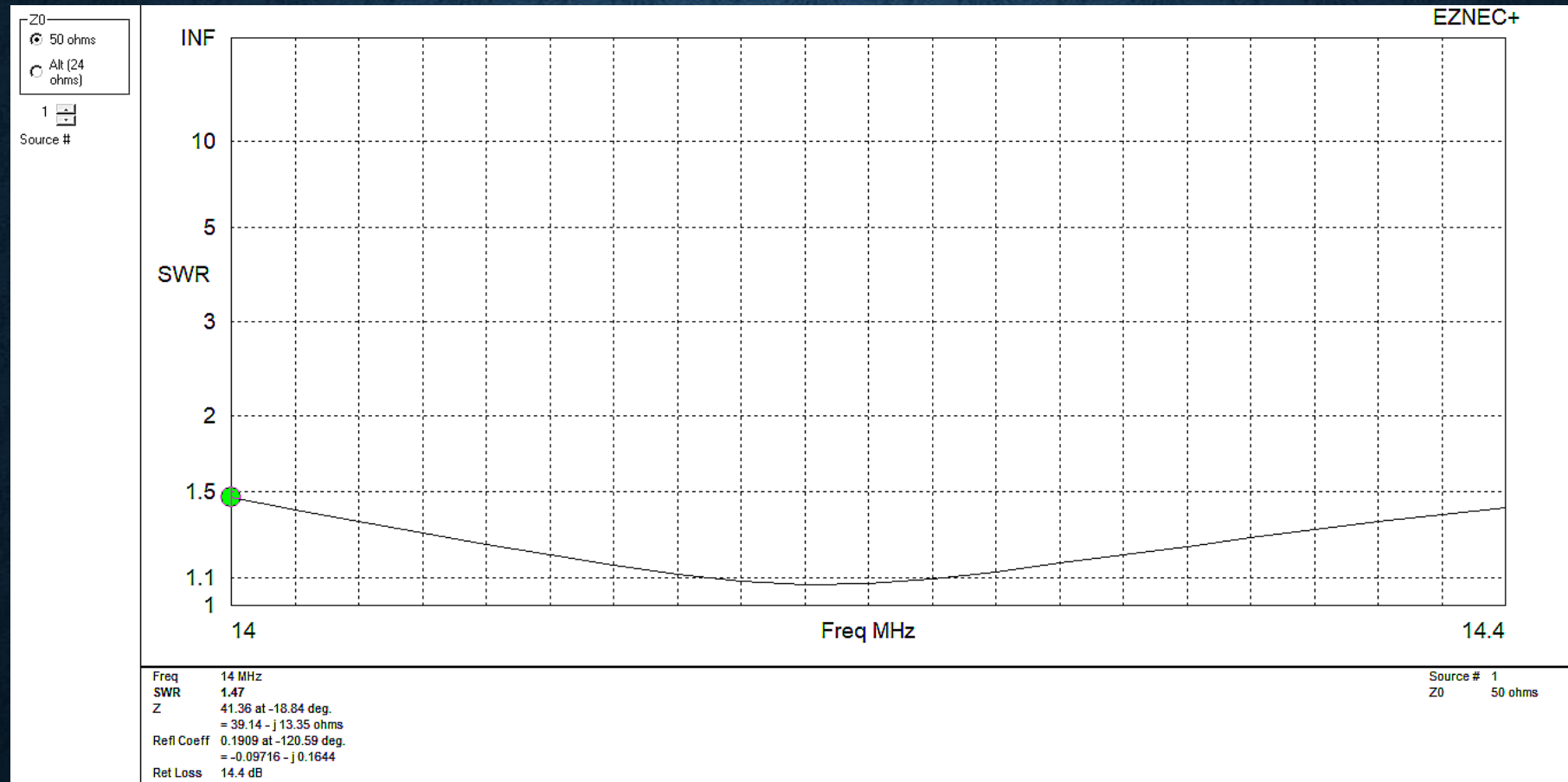


20M 4-el Yagi

Gain = 7.96 dBi

F/B = 22.97 dB

ULTRALIGHT BEAM EXAMPLES: 20M



20M 4-el Yagi

SWR < 1.5:1 across entire band (1.08:1 @ 14.175 MHz)

SUMMARY: 20M ULTRALIGHTS

Model	Gain	F/B	Size
20M: 2-EI	6.13 dBi	10.46 dB	12'/12 Lbs.
20M: 3-EI	6.8 dBi	26.9 dB	16.5'/16 Lbs.
20M: 4-EI	7.96 dBi	22.97 dB	25'/20 Lbs.

- 2-EI yields most Gain for least weight and boom length
- 3-EI and 4-EI provide significant Pattern advantages
- 4-EI provides worthwhile (?) Gain advantage over 2-EI
- Is 3-EI the Orphan Child or best compromise?

ULTRALIGHT BEAM EXAMPLE: 15M

15M 3-el Yagi

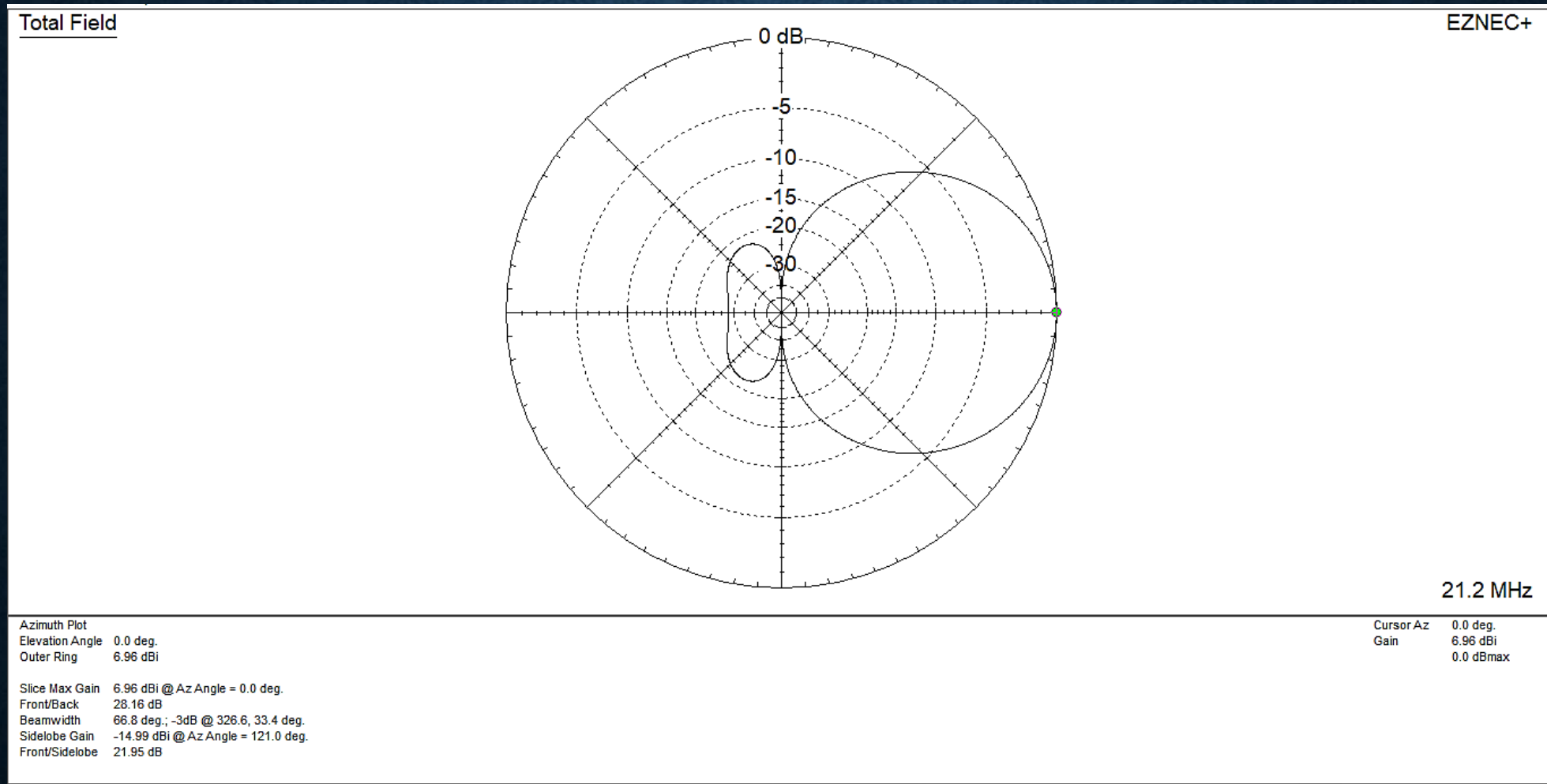
Boom Length: 12 Feet

Weight: About 14 Pounds

**Shown on test tripod on
roof**



ULTRALIGHT BEAM EXAMPLE: 15M

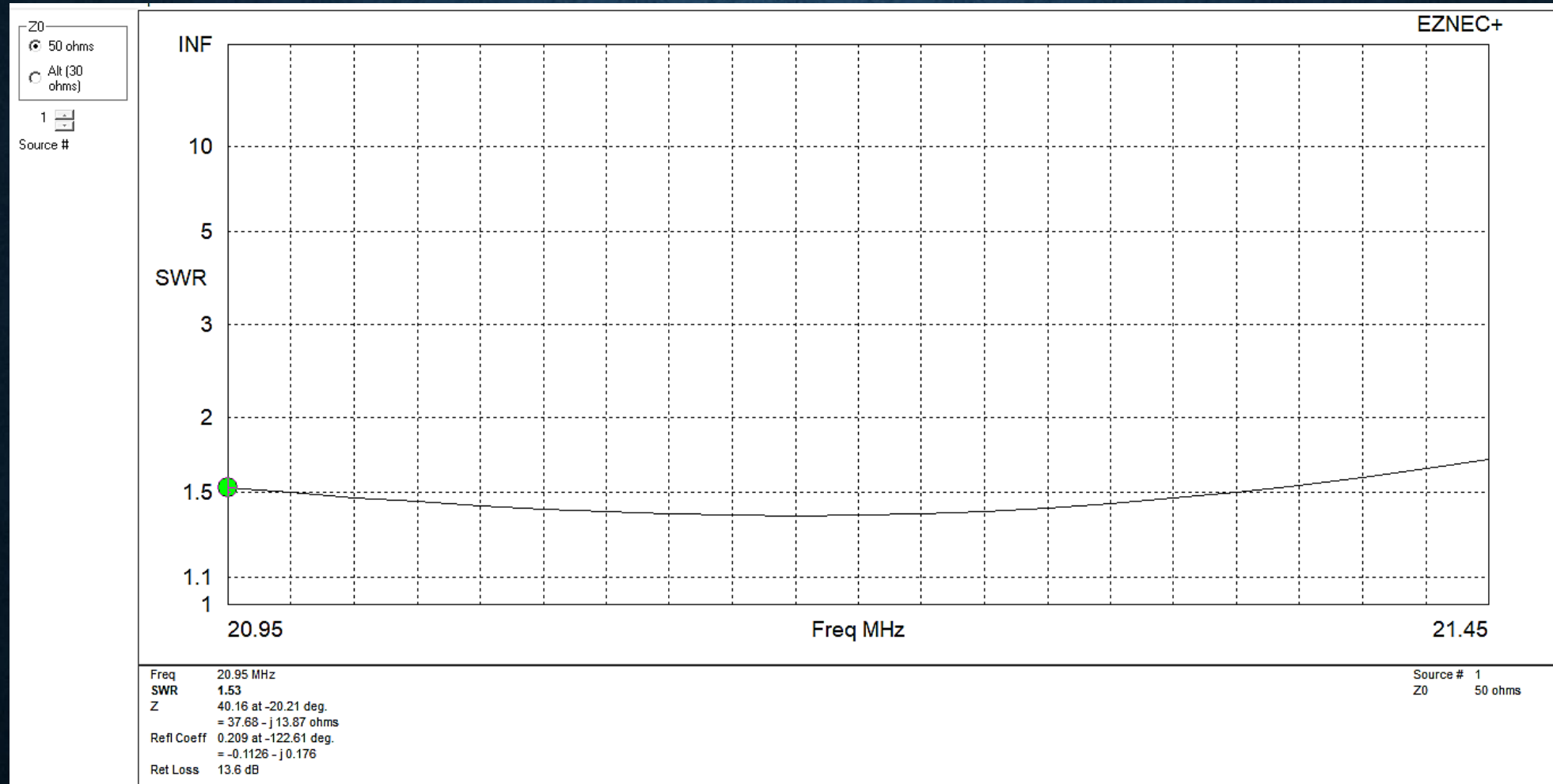


15M 3-el Yagi

Gain = 6.96 dBi

F/B = 28.16 dB

ULTRALIGHT BEAM EXAMPLE: 15M



15M 3-el Yagi

SWR < 1.65:1 across entire band (1.37:1 @ 21.225 MHz)

ULTRALIGHT BEAM EXAMPLE: 10M

10M 3-el Yagi

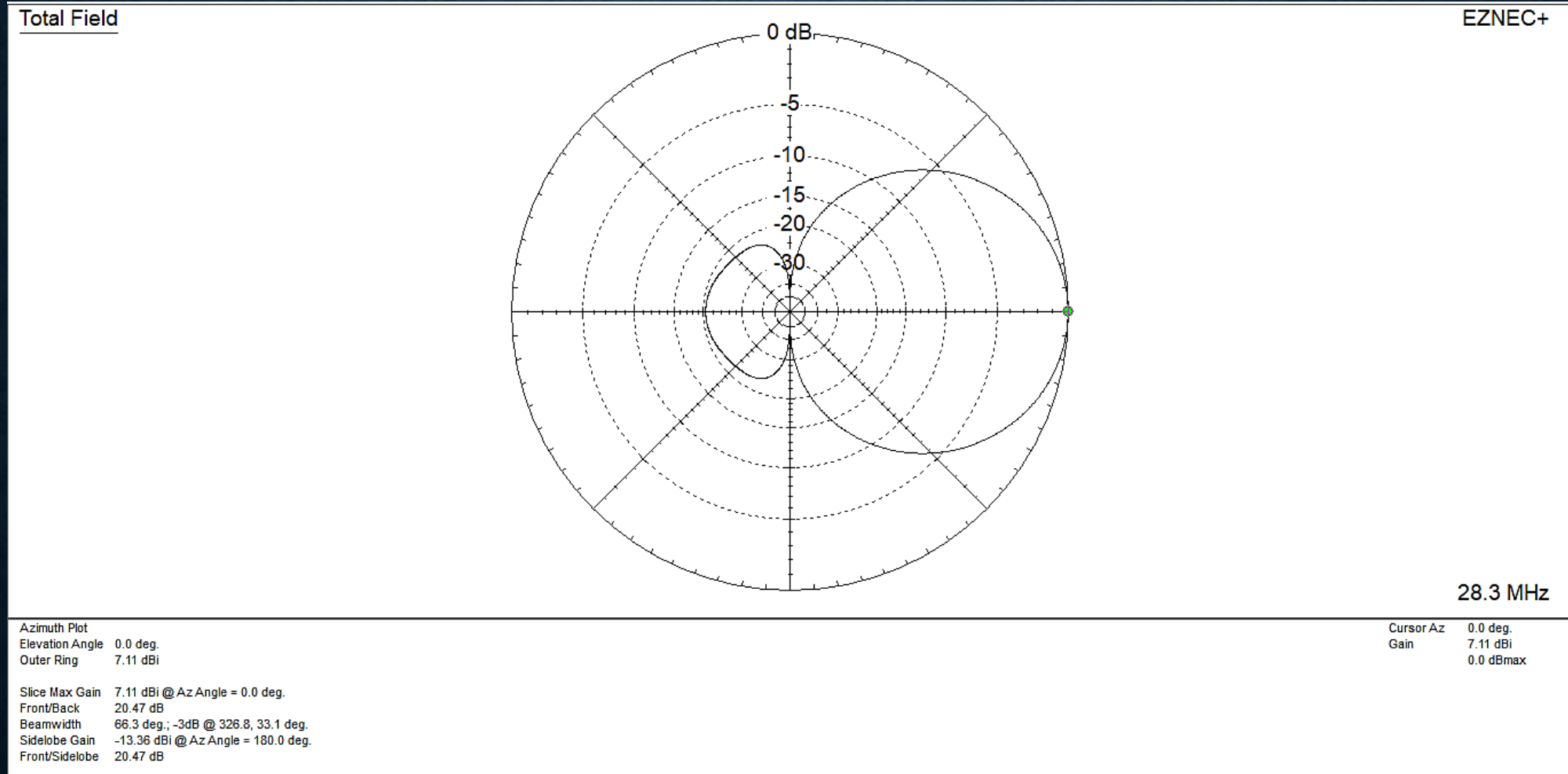
Boom Length: 9.5 Feet

Weight: About 12 Pounds

Shown on test tripod on
roof



ULTRALIGHT BEAM EXAMPLE: 10M

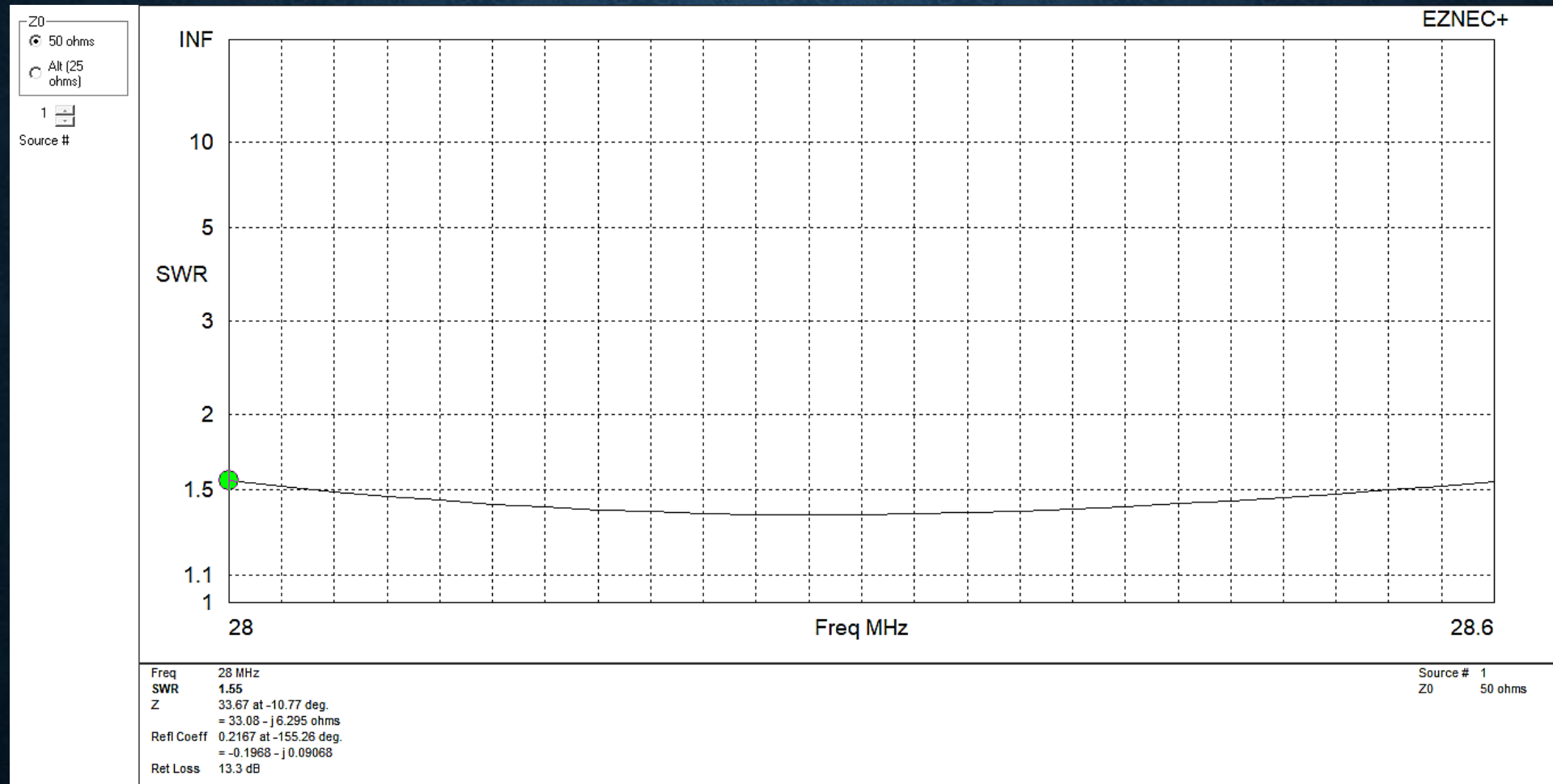


10M 3-el Yagi

Gain = 7.11 dBi

F/B = 20.47 dB

ULTRALIGHT BEAM EXAMPLE: 10M



10M 3-el Yagi

SWR < 1.55:1 28.0 – 28.6 MHz (1.35:1 @ 28.300 MHz)

ULTRALIGHT BEAM EXAMPLE: 6M

6M 5-el Yagi

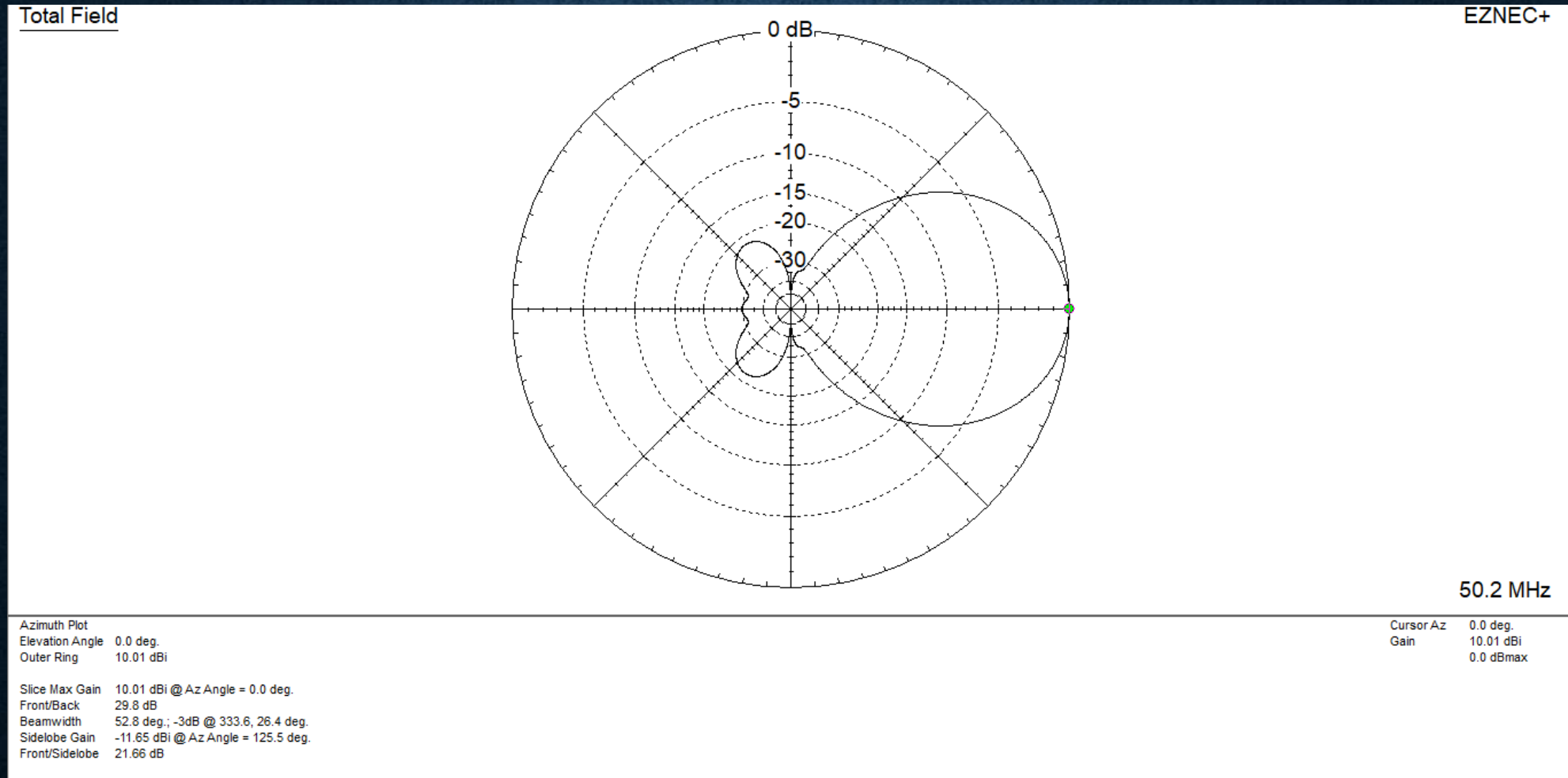
Boom Length: 12 Feet

Weight: About 15 Pounds

Shown on test tripod on
roof



ULTRALIGHT BEAM EXAMPLE: 6M

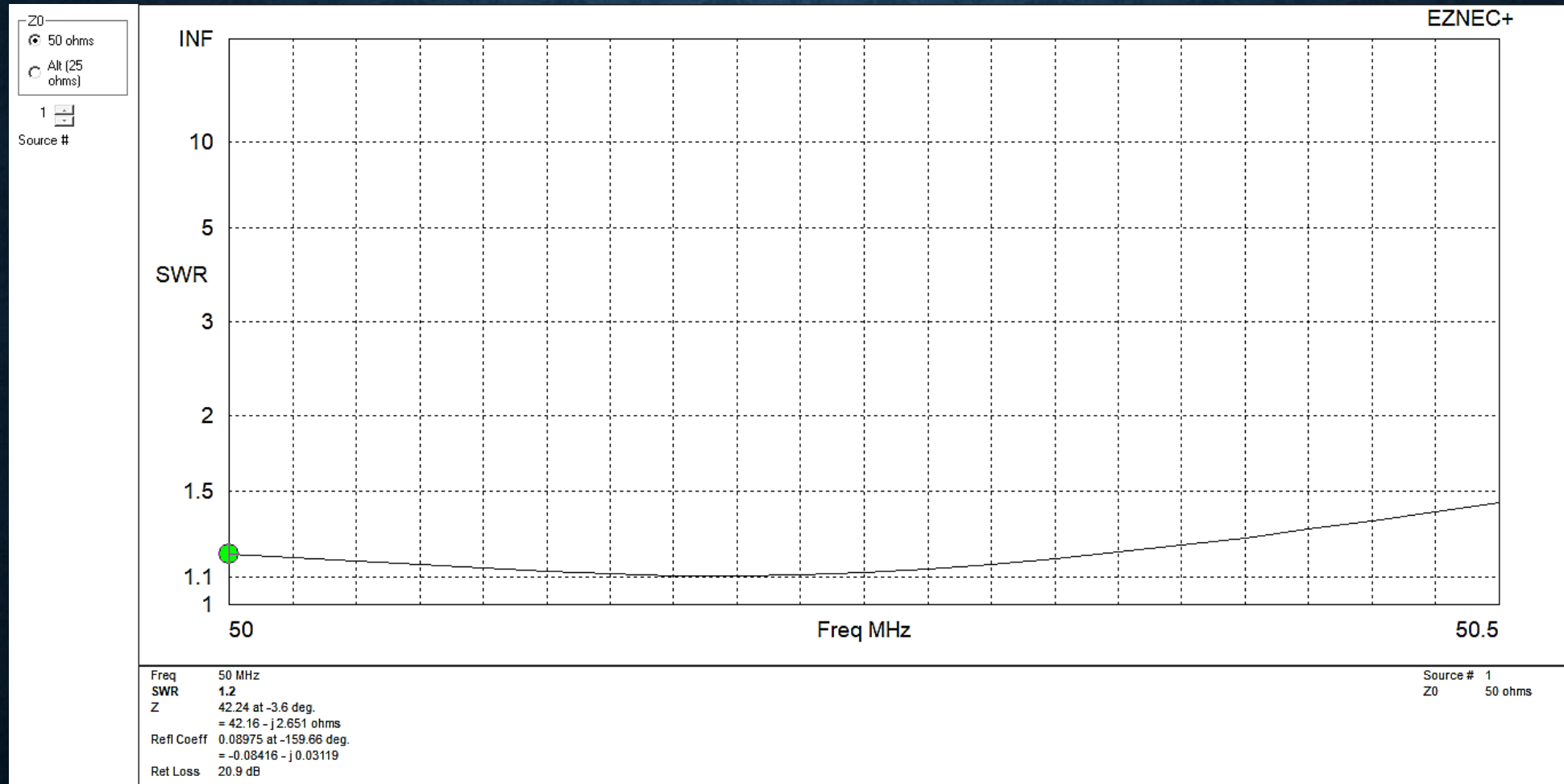


6M 5-el Yagi

Gain = 10.01 dBi

F/B = 29.8 dB

ULTRALIGHT BEAM EXAMPLE: 6M



6M 5-el Yagi

SWR < 1.4:1 50.0 – 50.5 MHz (1.1:1 @ 50.200 MHz)

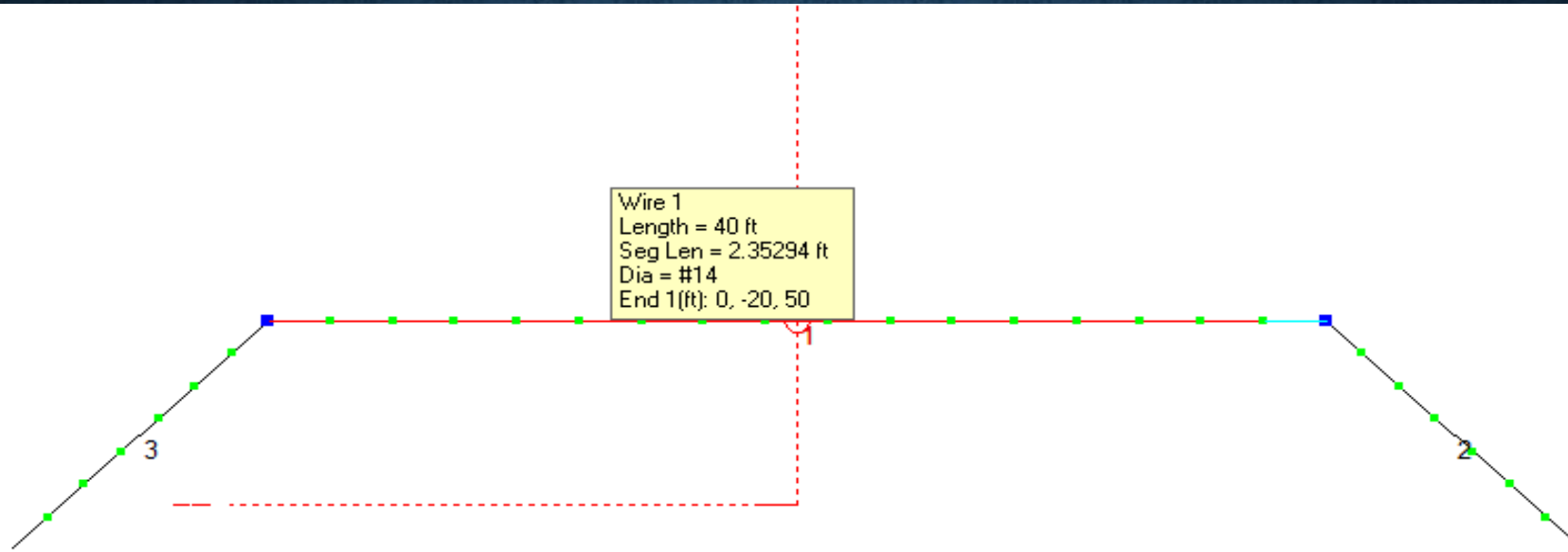
ABOUT 40 METERS

Yes, You Can! But...

- Crappie Poles 35' long do not exist (!).
- Must use hybrid pole plus drooping wires design.
- “Angle of the Dangle” is critical.
- Element concept superior to “Inverted Vee” type.



ABOUT 40 METERS



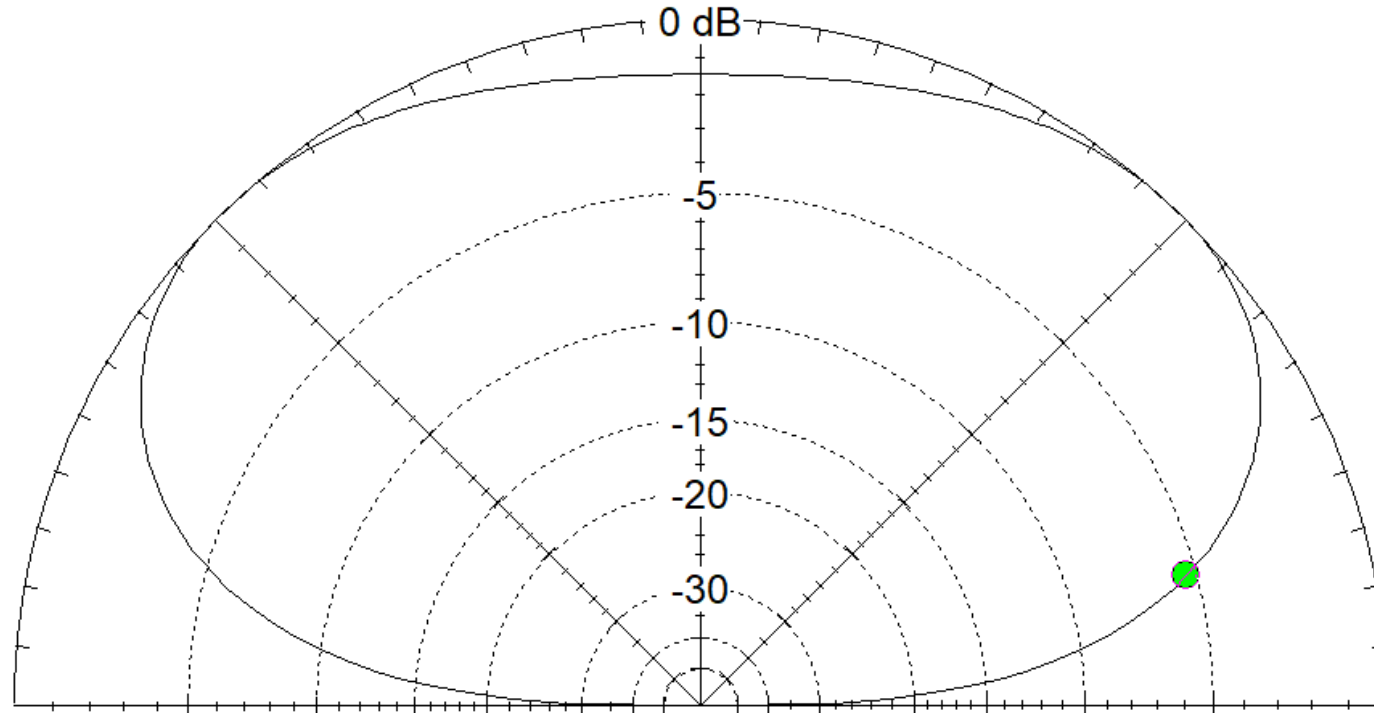
Cootie Element

Max current portion of element is flattop, increasing average height of element compared to inverted vee.

ABOUT 40 METERS

Total Field

EZNEC+



7.2 MHz

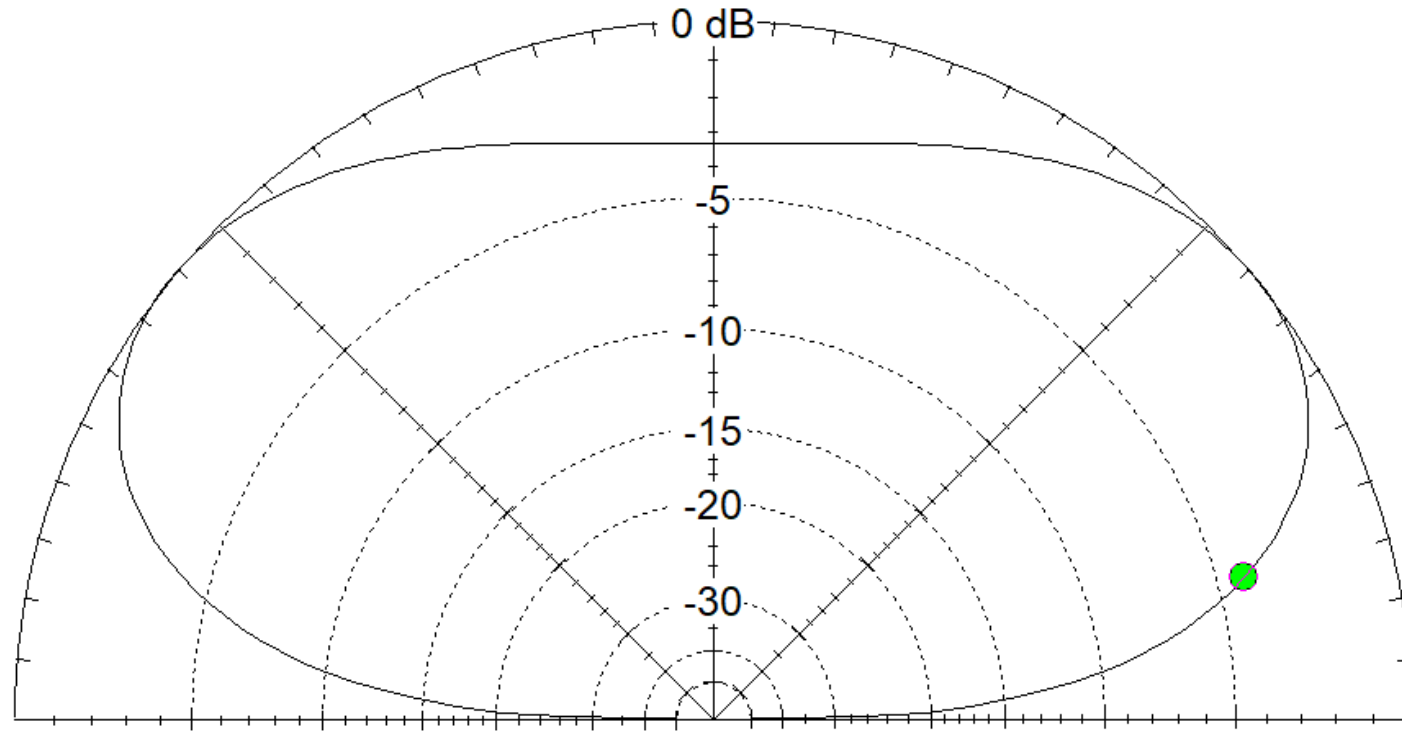
40M Inverted Vee@50'

Max Gain: 5.49 dBi @ 49° Elevation; 0.15 dBi @ 15°

ABOUT 40 METERS

Total Field

EZNEC+



7.15 MHz

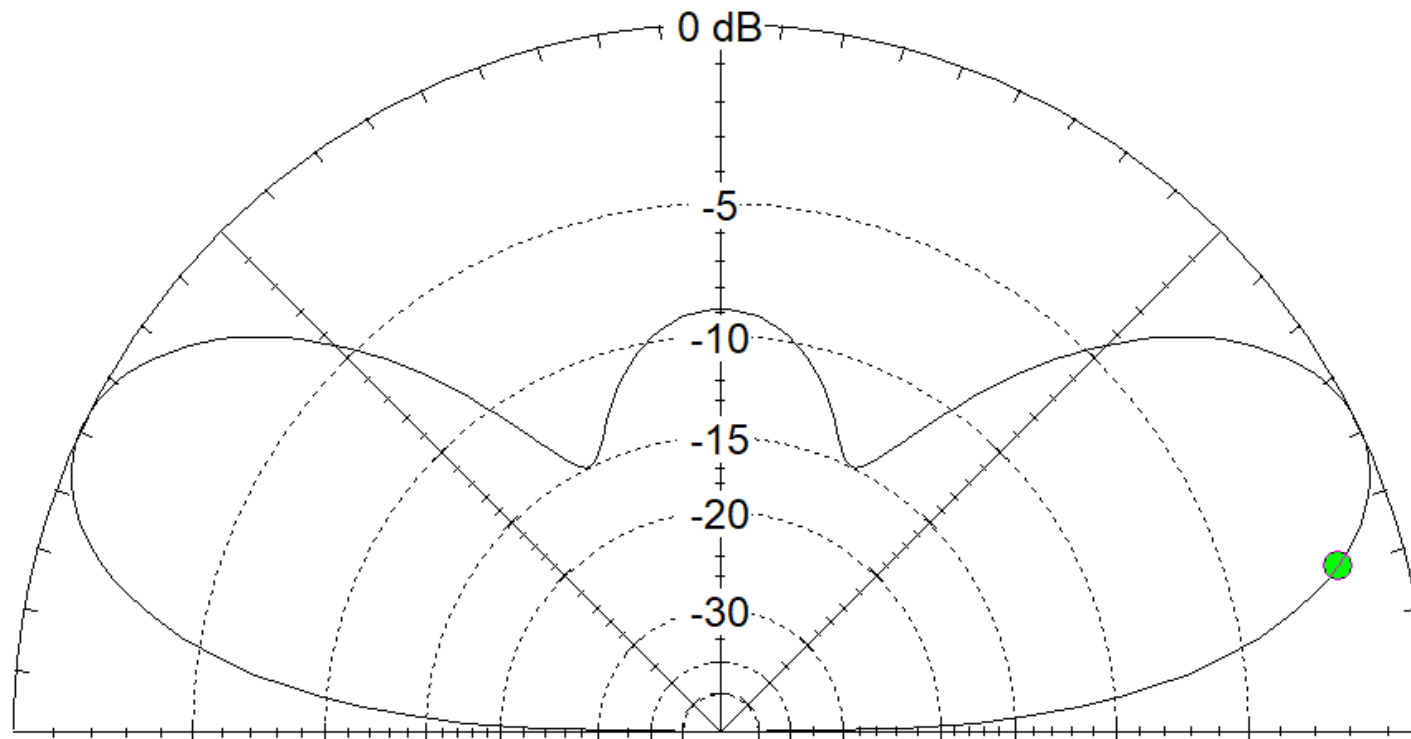
Cootie Element @ 50'

Max Gain: 5.53 dBi @ 39° Elevation; 1.39 dBi @ 15°

ABOUT 40 METERS

Total Field

EZNEC+

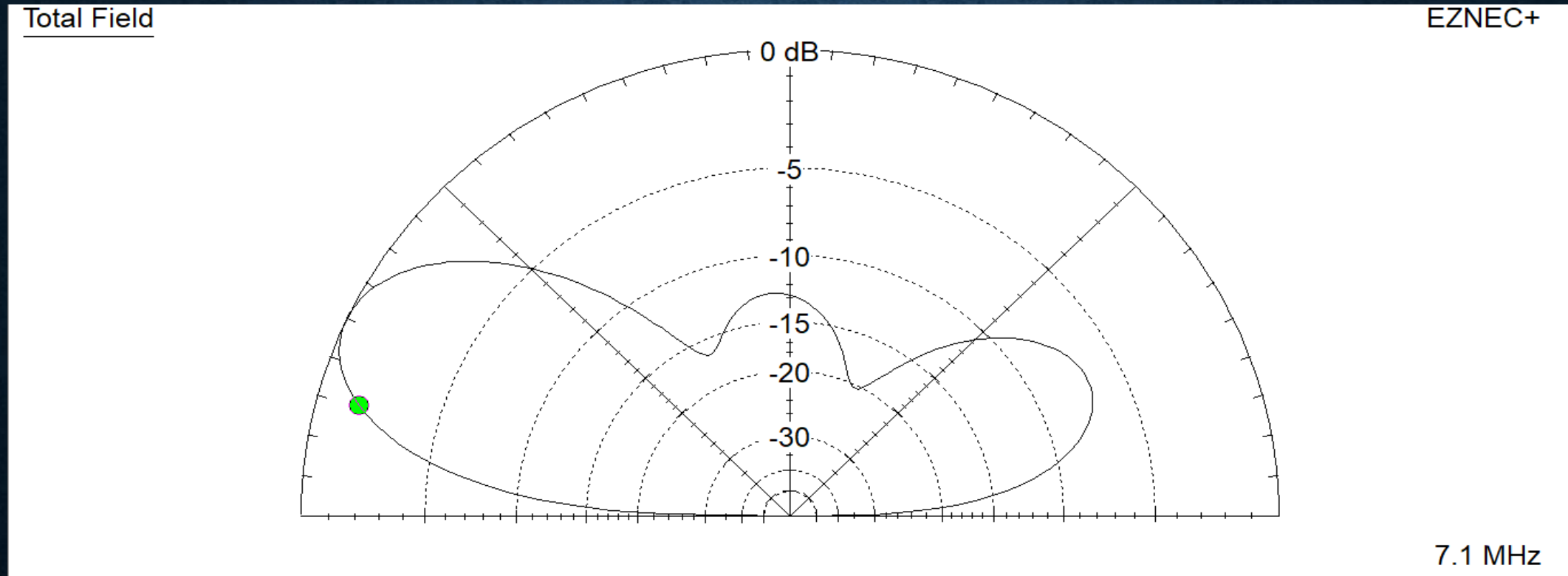


7.15 MHz

However...Cootie Element @ 75'

Max Gain: 7.88 dBi @ 25° Elevation; 6.13 dBi @ 15° !!!

ABOUT 40 METERS



Cootie 2-El Yagi (DE/Director) @ 75'

Max Gain: 10.34 dBi @ 25° Elevation; 8.74 dBi @ 15° !!!

Be loud, or be hosed.

ABOUT 40 METERS

Why Not?

All you need is a 110' motorized crank-up tower; it's the perfect demonstration of ham radio's emergency quick deployment capability!



ABOUT 40 METERS

A single Cootie Element
(like this one at WY7FD) can
be extremely loud from a
modest mast if your FD QTH
has a steep foreground
downward slope.

K7JA at WY7FD copying
W1AW Message at 599+
over an all-daylight path.



BE LOUD ON FIELD DAY

Having a puny signal on Field Day or a DX contest is no fun.

Coming home from FD totally exhausted is also no fun.

Ultralight beams can make life easier, and they work great!



BE LOUD ON FIELD DAY

You'll learn a lot as you design your dream beam, and you won't sap your strength putting it up.

**And you'll be
KB Loud!**



REFERENCES

- EZNEC Modeling Software: www.eznec.com
- B&M Crappie Poles: www.bnmpoles.com/products/bw
- #14 Wire: www.hamradio.com (and because I work there)

SPECIAL THANKS

To my wife Janet, KL7MF, who is a superb operator and, as the High Priestess of Car Packing, always finds a way to get all my “stuff” to fit in the car.

“K6 Monkey Monkey Monkey, you’re a dupe!”



HAVE FUN AND BE LOUD!

*Just don't be louder
than I am!!*

73 de Chip, K7JA

